PARTIAL TRANSLATION OF JAPANESE UNEXAMINED PATENT PUBLICATION (KOKAI) NO. 9-199302

SCOPE OF CLAIM FOR PATENT

1. A chip PTC thermistor comprising:

a substrate;

a first electrode layer formed on an edge portion of the upper surface of the substrate to provide a first opening;

an electrically conductive polymer layer having a PTC characteristic formed on the supper surface of the first electrode layer and on the first opening;

a second electrode layer formed on the upper surface of the electrically conductive polymer layer to provide a second opening on the edge portion opposite to the first opening;

a protective layer formed on the upper surface of the second electrode layer and on the second opening; and

side surface electrodes formed on both sides of the substrate and electrically connected to the first or second electrode layer on each side.

2. The chip PTC thermistor according to claim 1, wherein the first and second electrode layer consists of a resin containing metal powders.

3. The chip PTC thermistor according to claim 1, wherein the protective layer is a polyimide film.

4. A method of manufacturing a chip PTC thermistor comprising:

forming a plurality of first electrode layers on the upper surface of the substrate to provide a plurality of first openings;

forming an electrically conductive polymer layer having PTC characteristic on the upper surface of the first electrode layers and on the first openings;

forming a plurality of second electrode layers on the upper surface of the electrically conductive polymer layer to provide a plurality of second openings in an offset relationship with the firs opening;

forming a protective layer on the upper surface of the second electrode layers and on the second openings;

conducting a first dividing step of the substrate into strip pieces along the edges of the first and second openings;

forming a side surface electrode on both sides of the substrate, electrically connected to the first or second electrode layer on each side; and

conducting a second dividing step of the strip pieces into individual chips.

DETAILED DESCRIPTION OF THE INVENTION (Excerpt)

[0001] TECHNICAL FIELD OF THE INVENTION

The present invention relates to a chip PTC thermistor using a conductive polymer having a PTC (positive temperature

coefficient) characteristic, and methods for manufacturing the same.

[0005] A conventional PTC thermistor will be described below. A conventional PTC thermistor is comprised of electrically conductive polymer containing particulate electrically conductive filler dispersed therein, and exhibits a characteristic feature known as a PTC (positive temperature coefficient) characteristic. The electrodes used in conjunction with such electrically conductive polymer include, for example, single wires, metallic foils, metallic sheets, and the like, and such metallic foils are electrically connected to both surfaces of the electrically conductive polymer layer by soldering.

[0008] An object of the present invention is to provide a PTC thermistor characterized in that the change of resistance value due to the change of properties of the electrically conductive polymer is reduced and dislocation of the junction between an electrode and a metallic terminal is also reduced at the time of mounting it on a printed circuit board.

[0011] MODE FOR CARRYING OUT THE INVENTION

The invention of claim 1 is a chip PTC thermistor comprising: a substrate; a first electrode layer forming on an edge portion of the upper surface of the substrate to provide a first opening; an electrically conductive polymer layer having a PTC characteristic formed on the upper surface of the first electrode layer and on the first opening; a second electrode layer formed on the upper surface of the electrically conductive polymer layer to provide a second opening on the edge portion opposite to said first opening; a protective layer formed on the upper surface of the second electrode layer and on the second opening; and side surface electrodes formed on both sides of the substrate and

electrically connected to the first or second electrode layer on each side. In this PTC thermistor, the electrode and the terminal are formed into one integrated structure. Therefore, dislocation of the junction between an electrode and a metallic terminal is reduced even if they are heated at the time of mounting on a printed circuit board.

[0012] The invention of claim 2 is a modification of the invention of claim 1, and has an advantageous effect in that dislocation of the junction between the electrode and the electrically conductive polymer layer is reduced by incorporation of metallic powders in the resin of the first and second electrode layers.

[0013] The invention of claim 3 is a modification of the invention of claim 1, and has an advantageous effect in that no registration is needed during printing and a protective layer having any thickness can be easily obtained by using a polyimide film as a protective layer.

[0014] Further, the invention of claim 4 is a method of manufacturing a chip PTC thermistor comprising:

forming a plurality of first electrode layers on the upper surface of the substrate to provide a plurality of first openings;

forming an electrically conductive polymer layer having a PTC characteristic on the upper surface of the first electrode layers and on the first openings;

forming a plurality of second electrode layers on the upper surface of the electrically conductive polymer layers to provide a plurality of second openings in an offset relationship with the first openings;

forming a protective layer on the supper surface of the second electrode layers and on the second openings;

conducting a first dividing of the substrate into strip pieces along the edges of the first and second openings;

forming a side surface electrode on both sides of the substrate, electrically connected to the first or second electrode layer on each side; and

conducting a second dividing of the strip pieces into individual chips.

[0015] Such a method has an advantageous effect of facilitating excellent mass-productivity and decreased resistivity of the resulting element.

[0016] First Embodiment:

A chip PTC thermistor in one embodiment of the present invention and the method for manufacturing the same will be described below, with reference to the drawings.

[0017] Fig. 1 is a perspective sectional view of the chip PTC thermistor in one embodiment of the present invention.

[0018] In Fig. 1, reference numeral 1 represents a substrate made of alumina, and the like. Reference numeral 2 represents a first electrode layer consisting of an electrically conductive phenolic resin having a specific resistance of no more than 10^{-3} Ω•cm, located on an edge portion of the upper surface of substrate 1 to provide a first opening 3. Reference numeral 4 represents an electrically conductive polymer layer consisting of a

composition of a crystalline polymer and electrically conductive particles, located on the upper surface of first electrode layer 2 and on first opening 3. Reference numeral 5 represents second electrode layer consisting of an electrically conductive phenolic resin having a specific resistance of no more than 10^{-3} Ω·cm, located on an edge portion of the upper surface of electrically conductive polymer layer 4 to provide second openings 6 on the side opposite to first opening 3. Reference numeral 7 represents a protective layer consisting of an insulating epoxy-based resin, located on the upper surface of second electrode layer 5 and on second opening 6. Reference numeral 8 represents terminal electrodes located on the side surfaces of substrate 1 and electrically connected to first electrode layer 2 or second electrode layer 5 on each side.

[0019] A method for manufacturing the chip PTC thermistor having a structure as illustrated above will be described hereinafter by referring to the drawings.

[0020] Fig. 2 through Fig. 6 are procedural drawings showing a method of manufacturing the chip PTC thermistor according to one embodiment of the present invention.

[0021] First, as shown in Fig. 2, an electrically conductive phenolic paste having a specific resistance of no more than 10^{-3} Ω·cm is screen printed onto the upper surface of substrate 1 made from alumina, and the like, to provide first openings 3, and baked at a temperature of about 150°C for about 30 minutes to form a plurality of first electrode layers 2.

[0022] Then, 51 weight % of a high density polyethylene having a crystallinity of 70 to 90%, 43 weight % of carbon black having average particle diameter of 58 nm and specific surface area of 38 m^2/g, manufactured by furnace method,

1 weight % of an antioxidant, and 5 weight % of a coupling agent are mixed and kneaded for about 20 minutes using two roll mills heated to about 150°C. Then, the kneaded sheet-like substance is taken out from the two-roll mill and cooled with pressing the sheet by a metallic plate to form a sheet having a thickness of about 0.2 mm, and this sheet-like substance is cut into a sheet having similar x-y dimensions to fabricate electrically conductive polymer layer 4.

[0023] Then, as shown in Fig. 3, conductive polymer layer 4 is laminated on first openings 3 of substrate 1 and on the upper surface of first electrode layers 2, and is heat pressed under a pressure of about 20 kg/cm^2 for about 10 minutes using a heat press machine heated to about 150°C to bond conductive polymer layer 14 onto the first openings 3 of the substrate 1 and on first electrode layers 2.

[0024] Then, as shown in Fig. 4, an electrically conductive phenolic paste having a specific resistance of no more than 10^{-3} $\Omega\cdot cm$ is screen printed on the upper surface of electrically conductive polymer layer 4 to provide a plurality of second openings 6 in an offset relationship with first openings 3, and cured at 120°C at 30 minutes to form a plurality of second electrode layers 5.

[0025] Then, as shown in Fig. 5, an insulating epoxy resin is screen printed on the upper surface of second electrode layers 5 and on second openings 6, and dried at a temperature of about 120°C for 10 minutes to form protective layer 7. Further, electrically conductive polymer layer 4 is irradiated with an electron beam of 40 Mrad in an electron beam irradiation equipment to crosslink the high-density polyethylene included in the conductive polymer layer. After this irradiation step, the resulting sheet-like material is subjected to a first dividing step wherein the sheet-like material is cut in the direction parallel to the lengthwise

direction of first openings 3 using a dicing machine.

[0026] Then, as shown in Fig. 6, an electrically conductive phenolic paste is coated on the both side surfaces of the strip-shaped substrate produced by the previous step so that the electrically conductive phenolic paste is electrically connected to first electrode layer 2 and second electrode layer 5 on each side, and is cured at about 120°C for about 30 minutes to firmly fix it to substrate 1 to form side surface electrodes 8. After this step, the strip-shaped substrate is subjected to a second dividing step wherein the strip-shaped substrate is cut into individual chips in the direction perpendicular to the cut surface in the first dividing step using a dicing machine.

[0027] Lastly, a nickel plate and a solder plate are applied on the surface of side surface electrodes 8 to obtain a chip PTC thermistor.

[0028] The chip PTC thermistor according to one embodiment of the present invention, constructed and manufactured as described above, was mounted on a printed circuit board by reflow soldering. In a visual inspection test after mounting, no displacement of the electrodes could be found and the solder fillets between the side surface electrodes and printed circuit board were formed satisfactorily.

[0029] Fig. 7 is a graph that illustrates the relationship between the temperature and the resistance of the chip PTC thermistor according to one embodiment of the present invention. The characteristic features as shown in this graph were obtained by measuring the resistance of the chip PTC thermistor with increasing the temperature from 25°C to 150°C in a thermostatic chamber. The resistance of this thermistor at ambient temperature (25°C) was 0.6Ω. The

resistance changes rapidly when the temperature reaches about 120°C, and the same effect as that of the conventional thermistor can be obtained.

[0030] Although, in the embodiment of the present invention as illustrated above, first electrode layers 2, second electrode layers 5, and side surface electrodes 8 were made from an electrically conductive phenolic resin, they may be made from an epoxy-, urethane-, or polyester-based resin. Further, the same effect can be obtained even if protective layer 7 is made from a phenolic- or polyester-based resin, although protective layer 7 in the embodiment as illustrated above is an epoxy-based resin.

[0031] Further, the adhesion strength between conductive polymer layer 4 and first electrode layers 2 and between conductive polymer layer 4 and second electrode layers 5 can be improved if the surface roughness of first electrode layer 2 and second electrode layer 5 is not less than 0.1 μm by plasma etching, blasting, and the like.

[0032] A similar effect can be obtained by using a substrate made from a phenolic resin, and the like.

[0033] Still further, the nickel plating and solder plating after the first dividing step may be followed by the second dividing step, while nickel plating and solder plating are applied on side surface electrodes 8 after the second dividing step, in the foregoing description.

[0034] Second Embodiment:

A chip PTC thermistor according to another embodiment of the present invention and the method for manufacturing the same will be described hereinafter by referring to the drawings.

[0035] Fig. 8 is a perspective sectional view of the chip PTC thermistor in another embodiment of the present invention.

[0036] A reference numeral 11 represents a substrate made from alumina, and the like. A reference numeral 12 represents a first electrode layer consisting of an electrically conductive phenolic resin having a specific resistance of no more than 10^{-3} Ω·cm, located on one side of the upper surface of substrate 11 to provide a first opening 13. A reference numeral 14 represents an electrically conductive polymer layer consisting of a composition of crystalline polymer and electrically conductive particles, located on the upper surface of first electrode layer 12 and on first opening 13. A reference numeral 15 represents a second electrode layer consisting of an electrically conductive phenolic resin having a specific resistance of no more than 10^{-3} Ω·cm, located on one side of the upper surface of electrically conductive polymer layer 14 to provide a second opening (not shown) on the side opposite to first opening 13. A reference numeral 16 represents an insulating resin element consisting of an epoxy-based insulating resin, located on the upper surface of the second opening. A reference numeral 17 represents a protective layer consisting of an insulating resin 16, located on the upper surface of second electrode layer 15 and on insulating resin element 16. A reference numeral 18 represents terminal electrodes located on the side surfaces of substrate 11, to electrically connected to first electrode layer 12 and second electrode layer 15 on each side.

[0037] A method for manufacturing the chip PTC thermistor having a structure as illustrated above will be described with reference to the drawings.

[0038] First, an electrically conductive phenolic paste

having a specific resistance of no more than 10^{-3} Ω•cm is screen printed onto the upper surface of substrate 11 made from alumina, and the like, to provide first openings 13, and baked at a temperature of about 150°C for about 30 minutes to form first electrode layer 12.

[0039] Then, 51 weight % of a high density polyethylene having a crystallinity of 70 to 90%, 43 weight % of carbon black having average particle diameter of 58 nm and specific surface area of 38 m^2/g, manufactured by furnace method, 1 weight % of an antioxidant, and 5 weight % of a coupling agent are mixed and kneaded for about 20 minutes using two roll mills heated to about 150°C. Then, the kneaded sheet-like substance is taken out from the two-roll mill and cooled with pressing the sheet by a metallic plate to form a sheet having a thickness of about 0.2 mm, and this sheet-like substance is cut into a sheet having the same x-y dimension as that of substrate 11 to fabricate electrically conductive polymer layer 14.

[0040] Then, conductive polymer layer 14 is laminated on the first openings 13 of substrate 11 and on the upper surface of the first electrode layers 12, and is heat pressed under pressure of about 20 kg/cm^2 for about 10 minutes using a heat press machine heated to about 150°C to bond conductive polymer layer 14 onto first openings 13 of the substrate 11 and first electrode layers 12.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective sectional view of a chip PTC thermistor according to one embodiment of the present invention.

Fig. 2 to Fig. 6 are procedural drawing showing the method for manufacturing the chip PTC thermistor of one

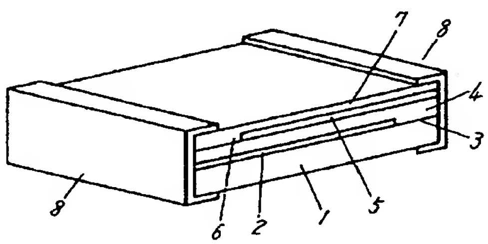
embodiment of the present invention.

Fig. 7 illustrates a relationship between the temperature and the resistance of the chip PTC thermistor of one embodiment of the present invention.

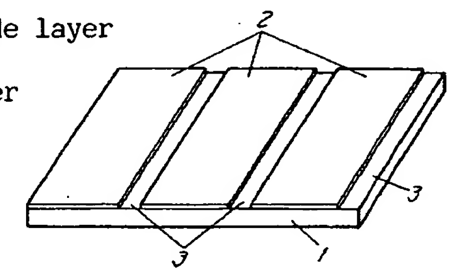
Fig. 8 illustrates a perspective sectional view of the PTC thermistor of another embodiment of the present invention.

[Fig. 1]

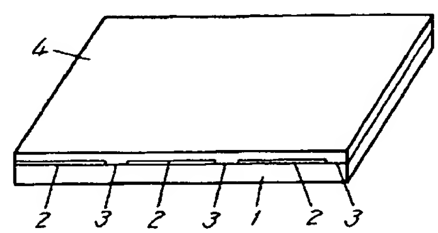
1 Substrate
2 First electrode layer
3 First opening
4 Conductive polymer layer
5 Second electrode layer
6 Second opening
7 Protective layer
8 Side surface electrode



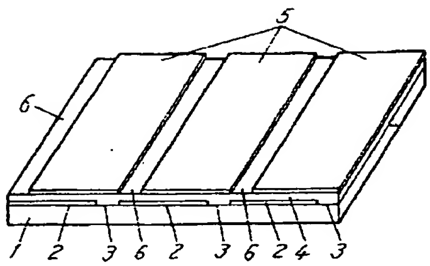
[Fig. 2]



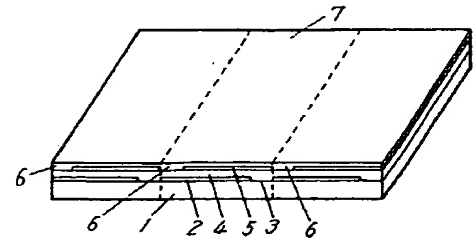
[Fig. 3]



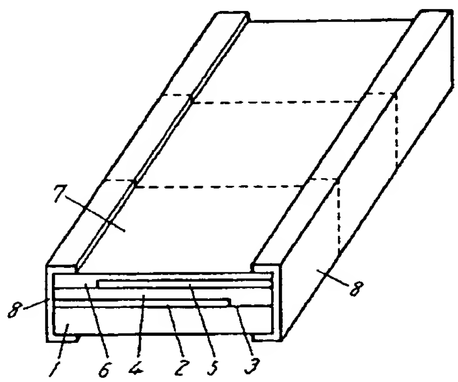
[Fig. 4]



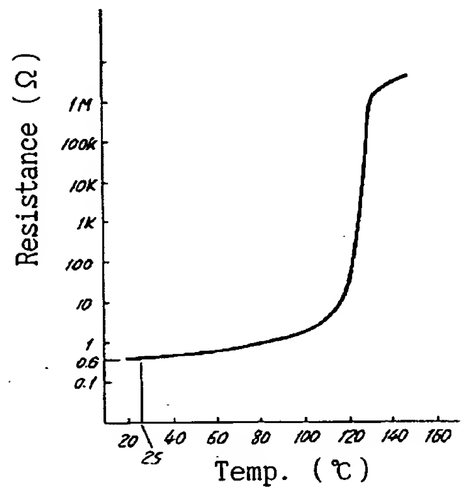
[Fig. 5]



[Fig. 6]



[Fig. 7]



[Fig. 8]

11 Substrate
12 First electrode layer
13 First opening
14 Conductive polymer layer
15 Second electrode layer
16 Insulating resin part
17 Protective layer
18 Side surface electrode